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FOREST HISTORY AND COMPOSITION OF HALFWAY POND ISLAND, PLYMOUTH COUNTY, MASSACHUSETTS

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ABSTRACT

The forest on a 6 hectare island in Halfway Pond is dominated by *Fagus grandifolia, Tsuga canadensis* and *Pinus strobus*. This composition contrasts with the vegetation around the pond, which is predominantly *Pinus rigida* and *Quercus ilicifolia*. Most large trees on the island are 150–200 years old, with a few 300-year-old *Nyssa sylvatica*. Growth ring analyses indicate that a hurricane in 1944 was the most significant disturbance event in the last 130–150 years. Additional evidence suggests that the present composition and structure of the island forest reflect selective logging of large trees in the 18th and early 19th centuries.

Comparisons of the island's flora with fossil pollen spectra from nearby sites (Patterson and Backman, 1988) suggest that the distinctive vegetation on Halfway Pond Island has been maintained for centuries and is not representative of regional pre-settlement forests, which were predominantly white pine and oak. Fire has probably always been less frequent on the island than on the surrounding landscape, a factor that would account for these differences in composition.

Key Words: 1944 hurricane, fire, forest history, fossil pollen, southeastern Massachusetts

INTRODUCTION

The unusual natural history of Halfway Pond Island (Plymouth County, Massachusetts) has been locally recognized for many decades. Tall forests of beech (*Fagus grandifolia* Ehrh.), hemlock (*Tsuga canadensis* (L.) Carr.), and white pine (*Pinus strobus* L.) that cover the 6 hectare island stand in sharp contrast to the pitch pines (*Pinus rigida* Mill.) and scrub oaks (*Quercus ilicifolia* Wang.) of the pine barrens around the pond. These differences have led to claims that the island "contains what is believed to be one of the oldest forests remaining in Massachusetts" (Nature Conservancy, 1982). Several reports describe the flora and fauna of the island (Lloyd-Evans, 1975; Richardson, 1976, *see* reference below). The site was acquired by The Nature Conservancy in 1978, and has been proposed for designation as a National Natural Landmark (Worley, 1980, *see* reference below).

Richardson (1976 unpubl. rpt., National Park Service) considered the island to be "an undisturbed representation of the original forest type" found in the surrounding Myles Standish pine barrens. This pre-settlement vegetation was extensively modified by agricultural land clearance, logging and fires (Patterson and Backman, 1988). Worley (1980 unpubl. rpt., National Park Service) questioned the characterization of the island's vegetation as unspoiled and pristine, pointing out cut stumps as evidence of past disturbance.

This study reconstructs the recent forest history of Halfway Pond Island through analyses of forest composition, structure, age and growth rates. In particular, I sought to determine whether the forest was an old-growth remnant of the pre-settlement vegetation of this region.

STUDY AREA

Halfway Pond Island is located in the center of Halfway Pond, a 110 ha kettlehole pond at the eastern edge of Myles Standish State Forest (Lat. 41°51′N, Long. 70°37′W). Most of the island is less than 2 m above water level, although a 5-m-high ridge runs along the south end (Figure 1). The soils are typically coarse and well-drained, characteristic of the glacial outwash that covers much of this area. About a hectare of the island is very close to pond level, and has swampy, poorly drained conditions.

The pond lies within the pitch pine-oak vegetation type (Westveld et al., 1956) characteristic of much of southeastern Massachusetts. The island is heavily forested, primarily by more mesic taxa such as beech and hemlock; the understory is generally open, with a sparse herbaceous layer. A dense shrub stratum occurs primarily only in the swamp.

METHODS

Forest composition was described from 8 east-west cross island transects. Each transect was separated from adjacent transects by 50 m. Point-centered quarter (PCQ) sampling of trees >10 cm dbh (diameter at breast height) was carried out at 10 m intervals along each transect. The dbh, distance, and species of the nearest tree in each of the four quarters was recorded (Cottam and Curtis, 1956). The frequency of understory species was measured by placing a 1-m-square quadrat at each point and recording the presence of all species within.

Forest history and age determinations were made by examining growth rings on increment cores collected from selected trees throughout the island (Figure 1). One core from each of 56 trees of 10 different species had been collected in 1981 by Ian Worley. This study used Worley's cores, supplemented by the maps and field notes that accompanied them, but all interpretations and analyses are my own. Cross-dating of these increment cores between trees on the island was generally possible for only a few decades before the present. With only one core per tree, I was unable to date most cores precisely through periods of suppressed growth, vague rings, and other growth irregularities.

Age determinations were made by counting to the innermost visible ring, estimating the number of additional rings to the center of the tree based on growth rates of the innermost rings, and adding a further correction (usually 8–25 years) for growth to the height at which the tree was cored. These two corrections introduce some uncertainty in age estimates for many specimens, although I judge that most ages are accurate to within ±15 years.

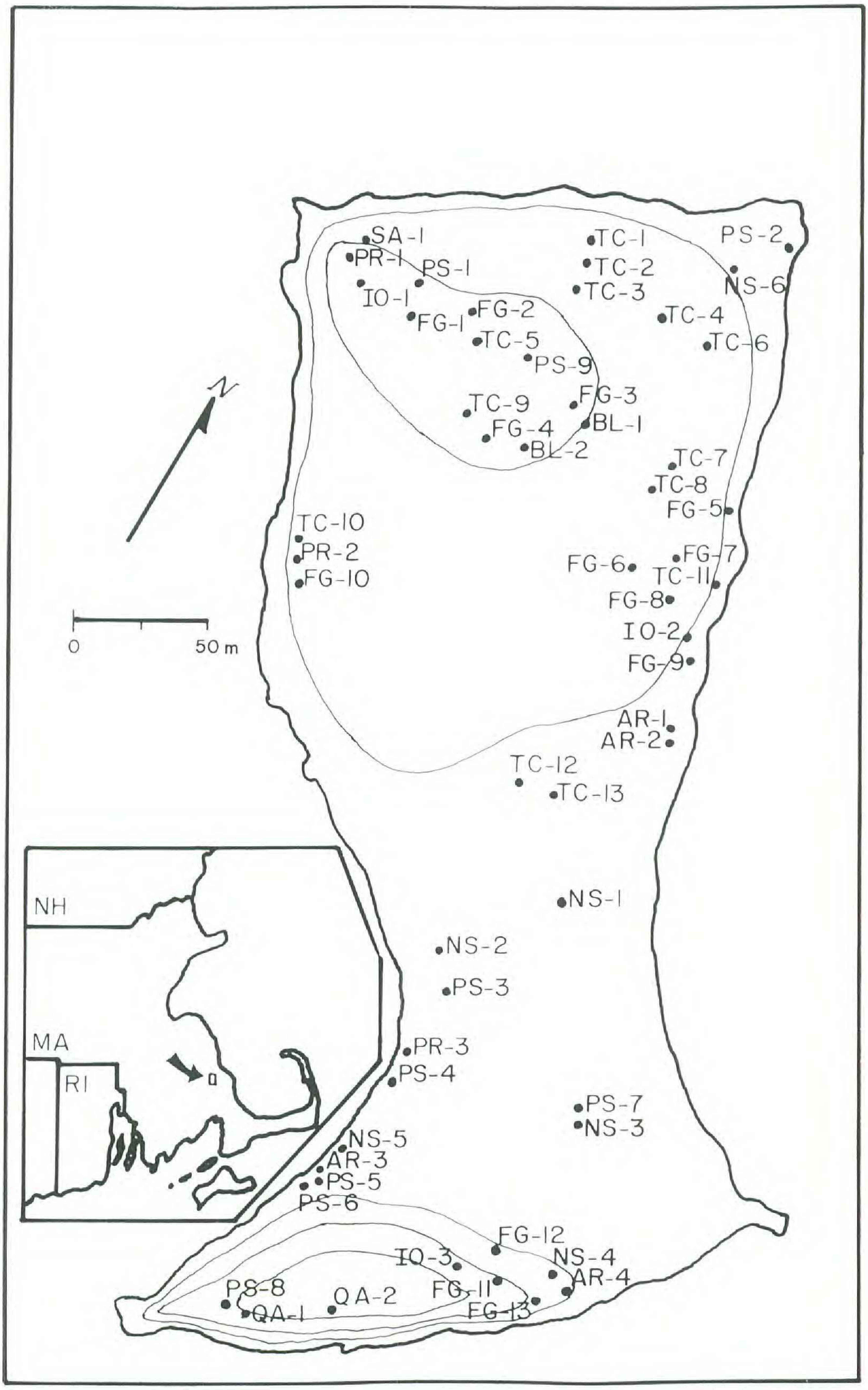
RESULTS

Forest Composition

Of the 16 tree species recorded on Halfway Pond Island, 12 were encountered at the 59 PCQ sampling points (Table 1). Other tree species which have been reported on the island include *Betula lenta* L., *B. populifolia* Marsh., *Prunus serotina* Ehrh. and *Quercus rubra* L.

The dominance of beech in the forest is emphasized in the frequency, density, basal area, and importance values of trees (Table 1). Beech ranks first in all four measures for trees >10 cm dbh. Evidence of beech-bark disease (*Nectria coccinea* var. *saginata* Lohman, Watson & Ayers) is present on some of the larger trees. Hemlock, red maple (*Acer rubrum* L.), white pine, tupelo (*Nyssa sylvatica* Marsh.) and yellow birch (*Betula lutea* Michx. f.) are the other dominant taxa, collectively comprising 95% of the basal area. In the understory, only *Clethra alnifolia* L. and *Maianthemum canadense* Desf. occurred frequently; they were found in 11 and 15 percent of the quadrats, respectively.

No data were collected to quantify dead and down wood. However, fallen snags, broken tops, and conspicuous tip-up mounds from uprooted trees attest to a history of windstorm damage,


SA-1
PR-1
PS-1
IO-1
FG-1
FG-2
TC-5
PS-9
TC-9
FG-3
BL-1
FG-4
BL-2
TC-1
TC-2
TC-3
TC-4
TC-6
PS-2
NS-6
TC-7
TC-8
FG-5
TC-10
PR-2
FG-10
FG-6
FG-7
TC-11
FG-8
IO-2
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AR-1
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NS-1
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PS-3
PR-3
PS-4
PS-7
NS-3
NS-5
AR-3
PS-5
PS-6
FG-12
IO-3
NS-4
AR-4
FG-11
FG-13
PS-8
QA-1
QA-2

Table 1. Summary of point-centered quarter data for all trees >10 cm dbh.

Species	Frequency	Density (trees/ha)	Basal Area (m/ha)	Relative Frequency	Relative Density	Relative Cover	Importance Value
Tsuga canadensis	58	124	8.67	22.5	22.9	28.5	73.9
Fagus grandifolia	76	205	11.37	29.8	37.7	37.4	104.9
Pinus strobus	20	35	4.13	7.9	6.4	13.6	27.9
Acer rubrum	32	62	2.04	12.8	11.4	6.8	31.0
Nyssa sylvatica	31	53	1.79	11.9	9.8	5.9	27.6
Betula lutea	15	32	.87	5.9	5.9	2.9	14.7
Ilex opaca	3	5	.06	1.3	.8	.2	2.3
Pinus rigida	3	5	.47	1.3	.8	1.6	3.7
Quercus alba	3	5	.18	1.3	.8	.6	2.7
Quercus velutina	5	7	.65	2.0	1.3	2.1	5.4
Sassafras albidum	7	9	.18	2.6	1.7	.6	4.9
Hamamelis virginiana	2	2	.03	.7	.4	.1	1.2
Overall		544	30.44				

especially to larger trees on the island. The northerly orientation of many fallen trees and mounds indicate that south winds account for much of this damage. The presence of occasional sawn stumps and logs of various sizes suggest that some wood has been removed from the island.

Age and Growth of Trees

Tabulations of age estimates and sizes for the 56 cored trees indicate that the oldest trees on the island are not the largest (Table 2). Two tupelos (NS-1, NS-6) had diameters of 48 and 62 cm and were estimated to have germinated in the late 1600's. Several other tupelos of similar sizes occur on the island and probably are also around 300 years old.

A gnarled, 15-m-tall white oak (*Quercus alba* L.) along the south ridge was the third oldest tree, dating back to the early 1700's (QA-1). The oldest beech, which also occurs on this ridge, is a stout, stunted tree about 180 years old (FG-12). Other beeches

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Figure 1. Topographic map of Halfway Pond Island, showing the approximate locations of the 56 cored trees. Contour interval is 2 meters. Species and age information are on individual trees listed in Table 3. Abbreviations are first letters of genus and species.

Table 2. Summary data of cored trees. Locations mapped in Figure 1. The approximate uncertainty in the germination date estimates can be determined by combining the number of years added to estimate the pith date and the estimated age at coring height. Species are coded by first letters of genus and species from Table 1.

ID Code	Diameter (cm) From Core	Diameter (cm) From Tree	Coring Height (cm)	Innermost Ring	Estimated Pith Date	Core Height Age	Germination Date
FG-1	45.4	47.5	51	1843	1838	15	1823
FG-2	35.0	41.7	48	1867	1862	15	1847
FG-3	31.0	31.5	36	1934	1930	10	1920
FG-4	35.0	38.1	46	1909	1909	14	1895
FG-5	48.8	64.5	38	<1878	1850	11	1839
FG-6	>46	42.9	43	1862	1855	13	1842
FG-7	29.4	32.3	61	1873	1860	18	1842
FG-8	30.0	25.4	30	1927	1900	9	1891
FG-9	36.0	59.9	56	1858	?	17	<1841
FG-10	53.2	55.9	61	1851	1840	18	1833
FG-11	39.0	41.7	46	1847	1845	14	1831
FG-12	32.6	43.2	132	1869	1850	40	1810
FG-13	51.4	51.3	51	1852	1842	15	1827
TC-1	52.8	56.6	61	1854	1830	18	1812
TC-2	25.4	25.7	38	1851	1830	11	1819
TC-3	17.6	15.7	30	1934	1930	9	1921
TC-4	68.4	71.6	38	1831	1815	11	1804
TC-5	29.4	37.6	36	1868	1860	11	1849
TC-6	66.4	69.9	61	1851	1830	18	1812
TC-7	22.8	25.4	30	1921	1921	9	1912
TC-8	14	13.7	30	1946	1946	9	1937
TC-9	44	59.7	46	1873	1860	14	1846
TC-10	64	71.9	91	1816	1800	30	1770
TC-11	40.8	46.5	38	1848	1843	11	1832
TC-12	64.8	70.1	66	1813	1805	20	1785
TC-13	>74.6	N.R.	N.R.	1827	≪1820?	20?	<1800
PS-1	60	72.6	61	1874	1860	10	1850
PS-2	62	76.2	46	<1873	1860	8	1852
PS-3	73.6	89.4	74	1860	1850	13	1837
PS-4	66	68.1	61	1836	1830	10	1820
PS-5	44	58.4	51	1851	1845	9	1836
PS-6	49	50.3	51	1864	1860	9	1851
PS-7	39.4	55.4	71	1850	1835	12	1823
PS-8	63	71.6	51	1858	1850	9	1841
PS-9	43	48.3	46	1950	1950	8	1942
PR-1	43.6	45.7	38	1839	1837	10	1827
PR-2	48	51.8	61	1848	1845	18	1835
PR-3	68	67.6	61	1824	1818	18	1800
IO-1	24	24.9	46	1862	1858	15	1843

Table 2. Continued.

ID Code	Diameter (cm) From Core	Diameter (cm) From Tree	Coring Height (cm)	Innermost Ring	Estimated Pith Date	Core Height Age	Germination Date
IO-2	26	N.R.	N.R.	1854	1848	8	<1840
IO-3	12	12.7	36	1914	1914	12	1902
QA-1	54	68.6	61	1773	1740	20	1720
QA-2	51	62.0	91	1849	1830	28	1802
NS-1	42	48.5	74	1735	1720	26	1694
NS-2	55.0	48.0	56	1850	1842	20	1822
NS-3	21.0	28.4	61	1854	1845	22	1823
NS-4	22.0	33.3	46	1870	1860	17	1843
NS-5	27.6	33.8	41	1873	1860	16	1844
NS-6	62.0	62.5	46	1691	1687	17	1670
SA-1	27.4	35.6	36	1860	1860	15	1845
BL-1	9.7	10.2	10	1956	1956	4	1952
BL-2	18.4	17.8	5	1946	1945	2	1943
AR-1	18.8	24.4	30	1949	1949	8	1941
AR-2	17.0	21.6	30	1948	1945	8	1937
AR-3	40.0	38.6	51	1837	1832	14	1818
AR-4	30.0	33.8	51	1860	1854	14	1840

exceeding 50 cm in diameter are not uncommon on the island. Individuals 40–60 cm dbh were usually 150–160 years old. The tallest trees, estimated to be 25–30 m, are the hemlocks and white pines. The oldest hemlocks appear to have germinated in the late 1700's (TC-10, TC-12, TC-13). White pines grow faster than the hemlocks, and none was found that became established before 1820. The largest pine was 89.4 at a height of .75 m, but was only about 150 years old (PS-3).

As with white pines and beeches, ages estimated from ring counts of large individuals of other species, including pitch pine, holly (*Ilex opaca* Ait.), sassafras (*Sassafras albidum* (Nutt.) Nees) and red maple, all yielded germination dates between 1800 and 1850 (Table 2).

DISCUSSION

Four types of information were used to identify the nature and date of disturbance events in the history of the Halfway Pond Island forest: 1) historical records, 2) field evidence in the form of tip-up mounds, uprooted or snapped trees, sawn logs and stumps, 3) inferences based on forest composition, size, age, and structure, and 4) changes in growth rates of trees determined from increment cores.

Historical Records

Steinway (1967) provided information regarding some of the earliest disturbance on the island. "Halfway Pond . . . has an island where large pine trees used to grow untouched by the forest fires that periodically ravaged the surrounding land. These trees were much prized in the 17th and 18th centuries for masts, and many were cut for the King's Navy as well as for local shipbuilders along the seacoast. The island . . . was once heavily wooded by beech, spruce, hemlock, and pine of immense size. The hurricane of 1938 took its toll of the virgin forest. Some of the fallen trees were lumbered and eventually 90 cords of firewood were taken off over the ice."

Allen (1981 unpubl. rpt., The Nature Conservancy) provided additional information regarding the recent storms. Trees in the area of the shrub swamp were "thought to have been damaged in 1938, while the trees at the northeast corner of the island and in the small clearing [near the north end] are thought to have been felled in 1944." She goes on to suggest that the 90 cords of wood, largely from downed trees, were removed following the 1944 hurricane.

Photographs provided by LeBaron Briggs documented the extensive damage from the September 14–15, 1944 storm, a hurricane whose path crossed almost directly over the pond. Photographs dated March, 1946 show extensive piles of wood cut to firewood dimensions stacked against many of the trees; another photograph shows a large pile of saw logs approximately 7 m long stacked along the shoreline.

Effects of the 1944 Hurricane

Evidence from the forest appears largely to confirm and augment these historical accounts. Steinway's (1967) description of large beech, hemlock, and, presumably, white pine continues to characterize the present dominant tree species, although her inclusion of spruce is doubtful. Tip-up mounds and fallen logs with

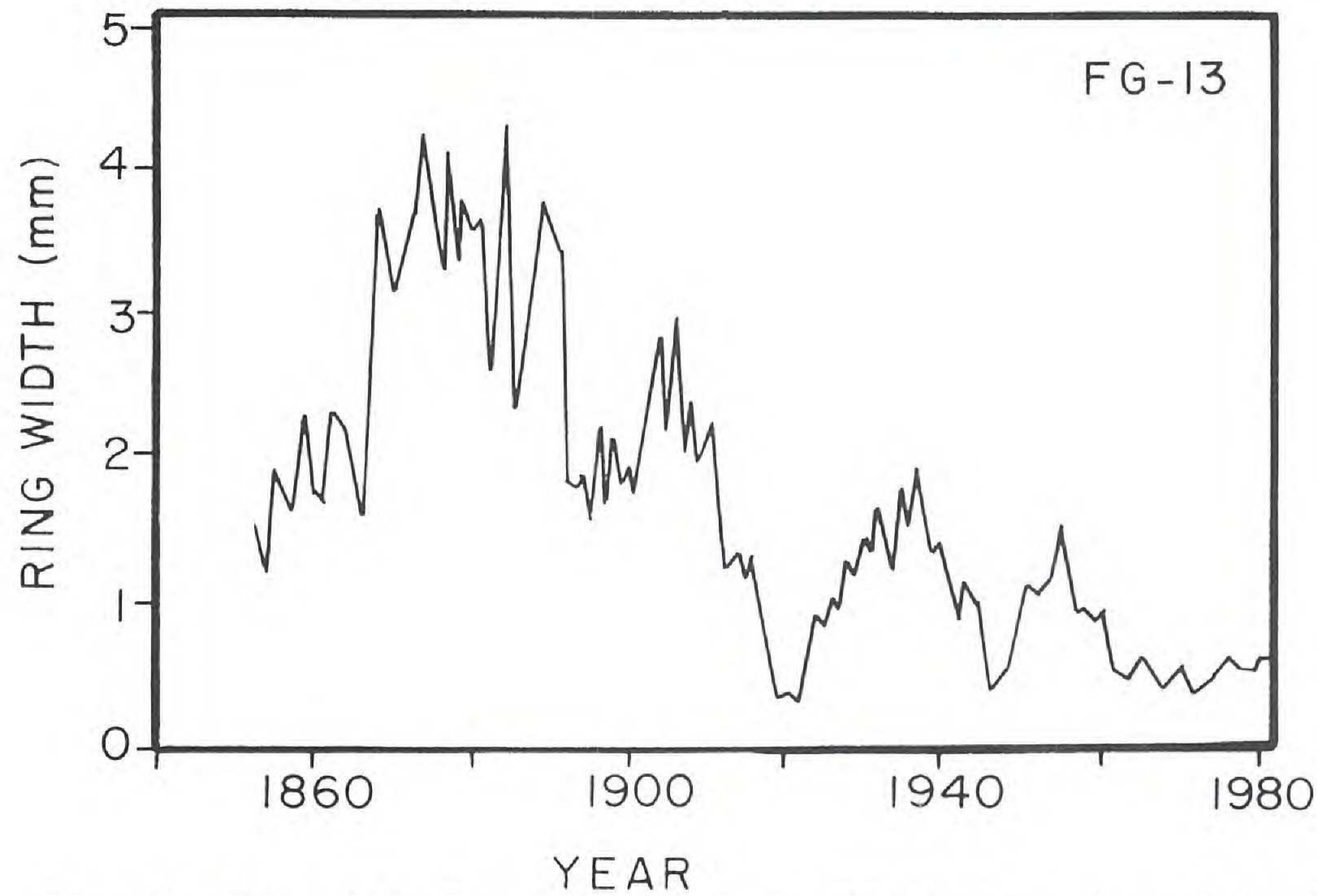

Figure 2. Ring widths from a beech tree, core FG-13, illustrating periods of suppressed growth beginning in 1945 and 1918, and a period of growth release about 1865.

an orientation of 350–360° occur frequently throughout much of the island. The condition of these features is generally in accord with a storm event dating 40–50 years ago. Sawn logs, and stumps often with a northward lean, also suggest salvaging of tipped and fallen trees followed this event.

Two opposite effects were noted among trees that survived the 1944 hurricane. A sharp reduction in the width of the 1945 ring, often followed by 3 to 7 additional narrow rings, was present among many white pines, hemlocks, beeches and some red maples, but only among individuals whose diameter in 1944 was >35–40 cm (Figure 2). Trees of this size probably were at, or emergent from, the canopy at the time of the storm and would have been the most likely individuals to suffer extensive breakage of limbs and snapping of roots due to excessive swaying. This damage would have resulted in a reduction in photosynthetic area and/or nutrient/water uptake, causing the observed reduction in growth.

An opposite effect was noted in trees whose diameter at the time was <15 cm (Figure 3). A large increase in growth, beginning in 1945, occurred among many of these small trees. The radial growth of hemlocks increased 4–8 times, and that of beeches as

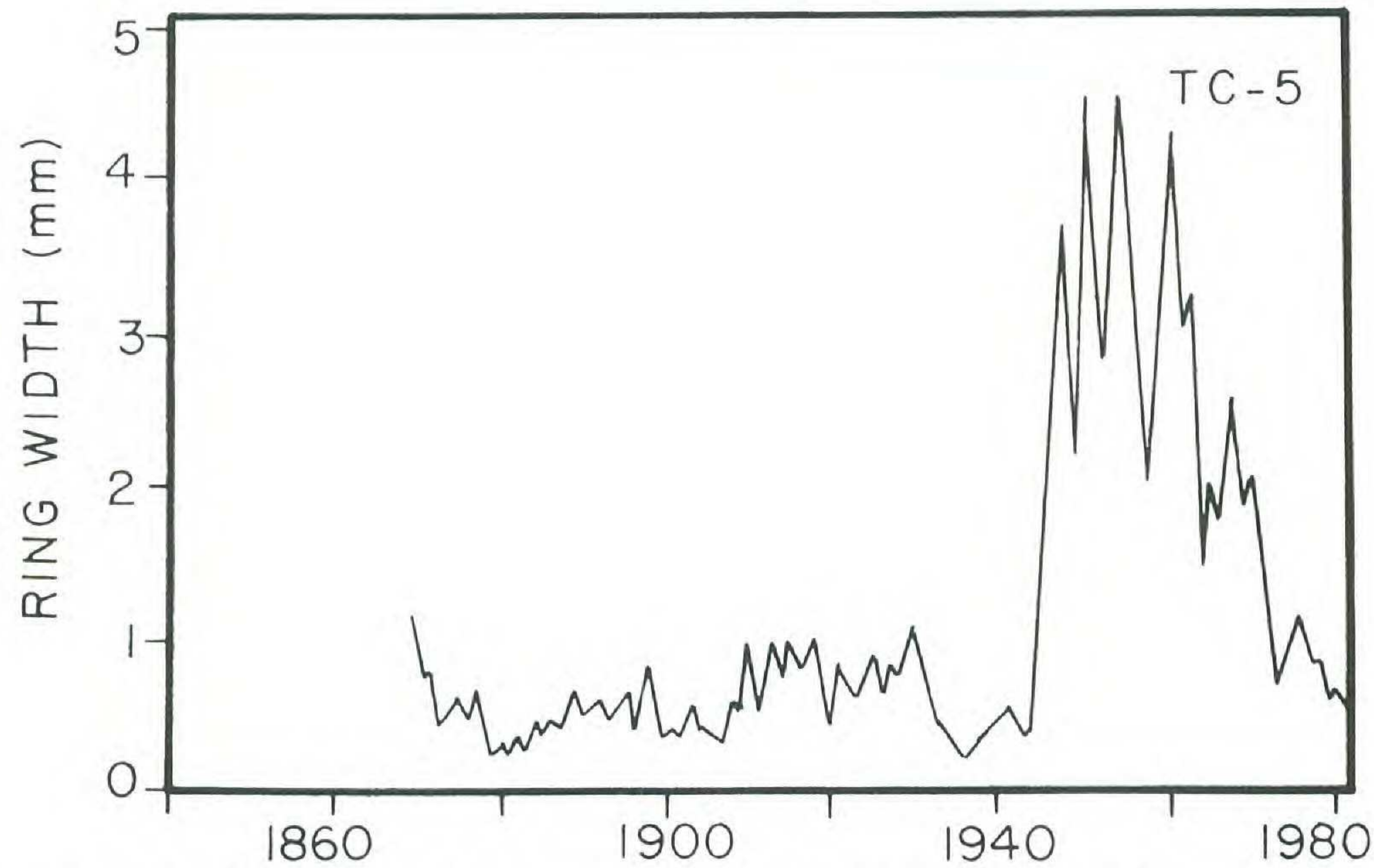

Figure 3. Ring widths from a hemlock tree, core TC-5, showing released growth following the 1944 hurricane.

much as 10–20 times the rate prior to 1944. Size rather than age appeared to be the factor that determined which trees would respond in this manner. Trees up to 100 years old that had been suppressed in the forest understory exhibited the same type of increase as younger individuals.

These abrupt changes in growth rates in 1945 were observed on 31 of the 56 individuals cored throughout the island. This pattern indicates that although historical reports of concentrated damage at the north end of the island may be accurate, ecologically significant impacts on both canopy and understory trees were widespread. The presence of saplings dating to the mid-1940's suggests that the 1944 hurricane also produced some regeneration on mineral soil exposed by upturned root systems.

Pre-1944 Disturbance Events

All cores were examined for growth ring patterns similar to those produced by the 1944 storm in order to determine the frequency of such occurrences in this forest. No effects could be seen in the cores that indicated significant effects from the 1938 hurricane. I suggest that this storm had relatively little impact on the island as a whole. Three other possible storm events were noted. Six large white pines show a significant reduction in growth beginning in 1955, and continuing for 2–7 years. Two hurricanes (Carol and Edna) passed through southern New England in August and September, 1954 and may have caused some damage to these trees.

Twelve trees, especially several beeches at the south end of the island, show pronounced growth reductions for 4–10 years beginning about 1918 (Figure 2), perhaps resulting from a large storm passing along the east coast on September 17–18, 1917 (Ludlum, 1986). A possible third event occurred about 1865, when 5 trees show a marked increase in growth that persisted for several decades (Figure 2). These were small trees at that time, and may have been released by a blowdown or logging that removed nearby individuals that had been suppressing their growth. From these results, it appears likely that the 1944 hurricane produced the greatest effects of any single storm on the island during at least the last 130–150 years.

Several lines of evidence suggest that some factor(s) removed large trees in the early- to mid-1800's, creating a relatively open forest at that time. First, only 6 of the cored trees germinated prior to 1800—3 hemlocks, 2 tupelos and a white oak. The scarcity of hemlocks exceeding 180 years old suggests that hemlock may have been selectively removed. Hemlock can live to 400–500 years, and the presence of much older tupelos suggests that a catastrophic disturbance did not destroy the entire forest during the period 175–300 years ago. Second, all the large white pines date from the first half of the 19th century. This species grows best in relatively open forest conditions, and all of the pines exhibit the extremely high growth rates typical of trees growing in the open. Third, the average growth rates of hemlocks and beeches during the mid-1800's, when they were young trees, are 3 to 6 times greater than comparable young trees growing in the forest 50 years later. This much higher growth rate is likely due to higher light levels in an open forest during the mid-1800's. Finally, the absence of old yellow birch, a species found as young trees growing on tip-up mounds in canopy gaps on the island today, may indicate that a different disturbance mechanism produced the open forest at that time.

Evidence suggests that the logging of large pines in the 17th and 18th centuries, cited by Steinway (1967), may have continued into the early 19th century and included large hemlocks and other merchantable species. Smaller, less valuable species such as tupelo, and gnarled trees such as the oak and beech along the exposed south ridge, were probably left uncut and account for the presence of older individuals of these species today.

The abundance of tip-up mounds throughout much of the island is another striking contrast with the landscape surrounding the pond. Although mounds cannot be used to date windthrow events precisely, they collectively indicate the importance of this type of disturbance among large trees. This difference with the terrain around the pond is further evidence for a long history of different vegetation and land use on the island, where trees reached sizes capable of producing large mounds when they fell.

I found no charred logs or fire scars on any trees on the island. Significant differences should occur in the abundance of charcoal in soils from on and off the island. Fires that may have started on the island probably were of low intensity, given the moister conditions and general lack of surface fuels, and would have little impact on the vegetation.

Comparisons with Pre-settlement Forests

Although documentation of these past disturbances to the island's forest challenge representations of the flora as "virgin," these data alone do not refute the possibility that this forest is similar in composition to the pre-European settlement vegetation. Fossil pollen studies of two ponds 5–8 km from Halfway Pond suggest that pre-settlement forests were dominated by oak and white pine (Patterson and Backman, 1988). Additional important species in the pollen record included hickory, beech, hemlock, and elm.

Comparisons of the present Halfway Pond Island vegetation with the pre-settlement record reconstructed from fossil pollen reveal important differences (Table 3). The percentages of beech, hemlock, red maple, tupelo, and yellow birch are considerably higher than represented by the pollen record, even when differential pollen productivity is taken into account. Similarly, black and white oak are much less abundant than would be expected if the island's vegetation were representative of pre-settlement forests. These differences suggest that the island's forests may have contrasted with surrounding areas even prior to European settlement.

Patterson and Backman (1988) suggested that occasional fires

Table 3. Comparison of Halfway Pond Island forest composition and pre-settlement forest taxa from fossil pollen.

Species	Island Trees*	Pre-settlement Pollen**
Fagus grandifolia	37.4	2–5
Tsuga canadensis	28.5	<5
Pinus strobus	13.6	20–25
Acer rubrum	6.8	<1
Nyssa sylvatica	5.9	<3
Betula lutea	2.9	0
Quercus spp.	2.7	30–40
Pinus rigida	1.6	<5
Carya spp.	0	<5
Ulmus spp.	0	<3

* Relative percent basal area of dominant island trees (from Table 1).
** Approximate percentages of arboreal pollen taxa prior to about 1700 A.D. (from Figures 3 and 4, Patterson and Backman, 1988).

were important in maintaining the pre-colonial pine-oak forests around the pond. Fires peripheral to the pond appear to have held succession at an earlier stage than on the island, where a more mesic, later successional vegetation developed because of less frequent fires and moister conditions. Thus large individuals of fire intolerant species such as hemlock and beech occurred more frequently on the island.

Around the pond, the scrub oak-pitch pine barrens were encouraged by colonial settlement, land clearance and a probable increase in more intense fires. These activities further increased the contrast between the island's forest and the surrounding landscape. Selective logging of merchantable timber on the island prior to 1850, as well as occasional storms, have allowed early successional species, especially white pine and red maple, to remain important components in the forest. Thus the vegetation today is not an undisturbed, old-growth stand, similar in composition to the regional pre-settlement forests. Rather, it is a product of both human and natural events imposed on a site that has remained free of fire to a much greater extent than any of the surrounding forests.

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LOST FARM
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